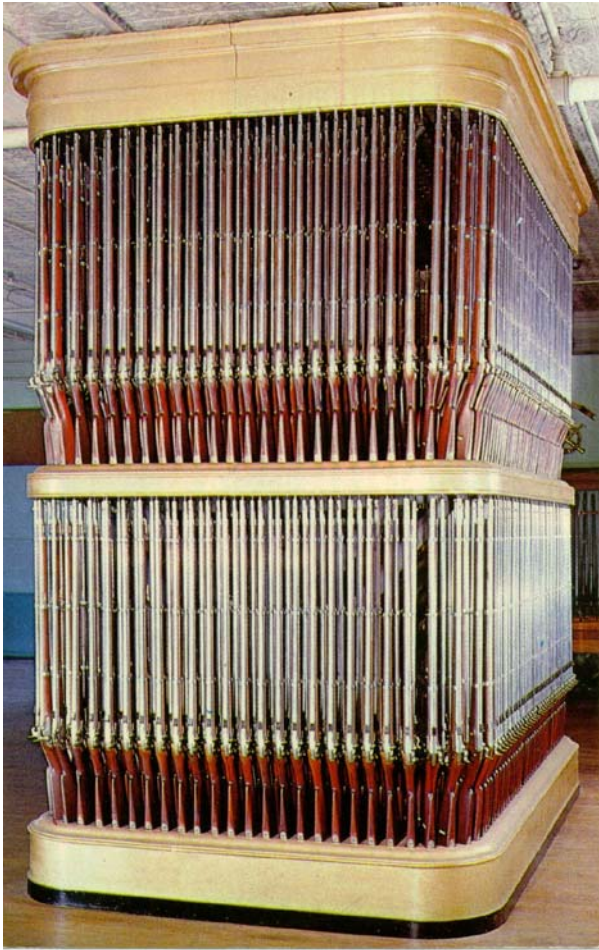


Springfield Armory: Technology in Transition

National Park Service
U.S. Department of the Interior

Springfield Armory
National Historic Site



This lesson explores the change in American manufacturing systems from individual production to mass production, made possible by the introduction of interchangeable and precision parts. The story of Springfield Armory illustrates how work and the roles of workers changed as technological innovations led to industrial growth.

This curriculum-based lesson plan is one of a thematic set on the Nineteenth Century using lessons from other Massachusetts National Parks. Also are:

[Boston Harbor Islands National Recreation Area](#)

The Fate of Liberty: The Role of Fort Warren in the Civil War

[The John H. Chafee Blackstone River Valley National Heritage Corridor](#)

Blackstone: A Case Study in Immigration

[Lowell National Historical Park](#)

Land Use in Lowell: Mapping Industrial Change

Included in this lesson are several pages of supporting material. To help identify these pages the following icons may be used:



To indicate a Primary Source page



To indicate a Secondary Source page



To Indicate a Student handout



To indicate a Teacher resource

Lesson Document

Link on the page to the document



[Springfield Armory National Historic Site](#) commemorates the change in American manufacturing systems from individual production to mass production, made possible by the introduction of interchangeable and precision parts. The story of Springfield Armory illustrates how work and the roles of workers changed as technological innovations led to industrial growth in antebellum New England and America. The developments at Springfield had a direct impact on the outcome of the Civil War and had far-reaching effects on many other aspects of American life.

In this lesson, students will create and use their own version of a simple machine that enables the production of interchangeable parts. They will also explore documents that reveal how the “American System” of manufacturing increased the production of arms, affected the outcome of the Civil War, and changed the roles of workers at Springfield Armory.

Enduring Understanding

The development of new technology and changes in manufacturing processes impact both the quantity of goods produced and the role of workers.

Essential Question

How did changes in the way goods were made at Springfield Armory affect production levels and workers' roles?

Content Objective/Outcomes	Language Objective/Outcomes
<p>The students will:</p> <ul style="list-style-type: none"> Explain how shifting from the unit method of production to mass production with interchangeable precision parts affected workers. Identify the Blanchard Lathe as one of Springfield Armory’s most important innovations and extrapolate its contribution to the growth of industry in America. Explain how the production of arms at Springfield Armory affected the outcome of the Civil War. 	<p>The students will:</p> <ul style="list-style-type: none"> Write coherent, well-organized paragraphs, demonstrating clear topic development, logical organization, effective use of detail, and variety in sentence structure. Integrate relevant information from group discussions to express their opinions and explain concepts they have discussed. Compare and contrast the working conditions associated with two different manufacturing systems.

Number of Days: 2

Intended Grade/Range: 8-12

Resources/Materials**Primary Source Documents:**

Excerpts from 1852 New Harpers Weekly article on production at Springfield Armory, also excerpts from several letters related to the interchangeable parts system.

Secondary Source Documents:

Excerpts from several documents describing arms manufacture and production.

Images: Image of wooden gun stock and Blanchard lathe patent drawing.

Worksheets: Classroom Pantograph activity and Exploration Handout.

Website: Springfield Armory National Historic Site at www.nps.gov/spar/, and nps.gov/spar/history.html

Forge of Innovation Website (Springfield Armory National Historical Site and University of Massachusetts).
<http://www.forgeofinnovation.org/>

Knowledge Required

To complete this lesson successfully, students will need the following:

- basic knowledge of pre-industrial craft production,
- knowledge of when, where, and why the Springfield Armory was established, and
- an understanding of the basic technologies used at the Springfield Armory, including the technology of interchangeable parts introduced by Eli Whitney early in the nineteenth century.

Students can find all necessary background information at the Springfield Armory National Historical Site website listed above.

Teaching/Learning Sequence**Launch:**

What manufacturing processes would make possible an increase in production at the Springfield Armory?

To help students answer this question, pose one or two of the following hypothetical situations to students:

- You need to make 20 identical cakes for a banquet. Which would be the most efficient way of getting the work done: mixing the cake batter with a fork or using an electric mixer?
- You are making cookies to sell in a bakery. Which method of cutting the cookies would be best to use: cutting the cookies out by hand or using a cookie cutter?
- You have been hired to paint street signs for the local town. You need to use a particular font and size of letter. Which would work best: lettering the signs by hand or using a stencil and spray paint?

Newer technologies obviously enable faster production (of cakes, signs, or anything else). When the Springfield Armory needed to develop faster methods of producing arms like muskets and rifles, it adopted methods that were part of the new concept of *mass production*, the relatively rapid production of a large number of identical items.

Pantograph Activity. Before the 1800s, items such as tools and weapons were created one at a time by skilled craftsmen. Each piece had to be fine-tuned to allow it to fit with other pieces. Some weapon parts, such as the gunstock (or wooden handle) of a rifle, had to be carved by hand.

One of the new inventions that helped make mass production of rifles possible was the Blanchard Lathe. The Blanchard Lathe was a machine that carved identical gunstocks out of blocks of wood, following a template or pattern as a guide. The workers could thus make many identical gunstocks rather than carving each one separately by hand.

Show students Image 1 of a wooden gunstock dating from 1835.

Tell them that they are going to do an activity that will help them understand the need for the Blanchard Lathe. Divide the class into small groups, Give each group a copy of the Pantograph Activity Sheet and the materials needed to complete it. Have students complete the activity sheet.

Show the patent drawing of Blanchard Lathe (Image 2) and watch the video of the working lathe at <http://www.forgeofinnovation.org/>.

Discuss the importance of precisely duplicated, standard-sized parts that are precision-made using the principle of the Blanchard Lathe. Ask students what they think the impact of using the lathe would be. How would it change production? Ask them to think about the skills involved in making a gun by hand versus making a gun using the lathe. How would the introduction of the lathe change the role of the worker?

Ask students for examples of how we use the principle of the Blanchard Lathe today. If students cannot come up with suggestions, ask them to think about how keys are made or how batteries for remote controls, flashlights, and cameras are standardized.

Vocabulary

Gunstock: the wooden handle of a rifle or musket.

Lathe: a machine that shapes wood or metal by rotating it against a cutting blade, using a template.

Pantograph: a tool or that duplicates patterns in two dimensions, such as a key-making machine.

Pattern: a design that can be copied to make identical versions of an item.

Template: a pattern used as a guide for cutting.

Armory: a place where weapons are made and/or stored for the military.

Mass production: rapid manufacture of a large number of a particular kind of goods.

Exploration:

Students will use primary and secondary sources to explore how mass production increased arms production and how new technologies affected workers.

Divide the class into four small groups. Tell students that each group will focus on a different question and use the resources provided to answer the question. When they report out, students will need to identify the primary and secondary sources that support their answer.

Assign each group a question from the list below and give them a copy of the documents they need to answer the question.

Give each student a copy of the Exploration Handout and have them collaborate to complete the handout. Give each group a copy of Document 1 (text and image).

Question 1: How did a worker's role and responsibility level change as a result of the introduction of interchangeable parts and mass production?

Documents:

- Document 2
- Document 3
- Document 4
- Document 5
- Document 6
- Document 11

Question 2: What were the key points in Eli Whitney's proposal that made it attractive to those in government?

Documents:

- Document 7
- Document 8
- Document 9
- Document 10

Question 3: How did the process of manufacturing change as a result of mass production?

Documents:

- Document 11

- Document 12

Question 4: How do you think the mass production of arms impacted the outcome of the Civil War? How did the ability to mass-produce affect production during the Civil War?

Documents:

- Document 13
- Document 14
- Document 15
- Document 16

Have students share the results of their group work. As a class, discuss how mass production changed the role of the worker and why this change was desirable for the nation.

Questions to consider:

- Why did Jefferson and others feel interchangeable parts for a musket would be worth developing?
- How did Eli Whitney plan to achieve interchangeability?
- How did the ability to mass-produce affect production during the Civil War?
- How did work at the Armory in 1852 differ from traditional hand production?

Summary:

In a whole-class discussion, ask students to summarize reasons why the U.S. government encouraged an increase in production at Springfield Armory, how mechanization made possible increased production, and what impacts these changes in the production process had on workers. Have students write two paragraphs summarizing the consequences of mass production versus individual production of non-standardized parts.

Assessment:

Explain to the class that they will debate the (fictional) issue of whether or not the U.S. government should enact a law requiring all gun factories to use mass production techniques to manufacture guns. One group supports the proposed law and the other group opposes it. A third group represents a combined committee of senators and members of the House of

Teaching/Learning Sequence

Representatives who will decide the outcome of the debate.

Work with the committee to develop the criteria for judging the debate. Communicate the criteria to the debate groups at the start of the activity.

Tell the debating groups that they have 15 minutes to develop an opening statement, three key arguments, and a closing statement. Have each debate team present its opening argument. Then, have groups alternately present their three main points. Finally, have each team present its closing argument.

Give the committee a couple of minutes to score the debate and then announce the results. The committee should be prepared to defend its decision.



The Power of Place

Site Visit:

Have you ever stood on the spot where some historical event occurred and felt a sense of awe and inspiration? This is the power of place you can experience when you visit a National Park. Historic places provide us with opportunities to connect with the lives of the generations before us. The power of place is that it gives history immediacy and relevance. As historian David McCullough* states, "When you stand there, in that very real, authentic place, you feel the presence of that other time, that history in a way that would be impossible did it not exist."

Visit Springfield Armory National Historical Site to see more evidence of the American Industrial Revolution, the evolution of interchangeable parts and precision manufacturing, and the impact of these innovations on the production of goods and on workers. Students can see a collection of historic military firearms, including the "Organ of Muskets" made famous by the Longfellow poem "The Arsenal at Springfield." Students can also see early American industrial tools and machinery used at the Armory to create interchangeable muskets, including an original Blanchard Lathe. Through exhibits in the visitor center, they can explore the effects on the Civil War of the use of interchangeable parts and the shift to mass production. Why was this shift in manufacturing important? How did it shape the way we work today?

Students can learn more about working in the armory at Springfield during the mid-1800s through participating in a curriculum-based education program at the park called "The Civil War: A Hands-On Approach to Soldiers, Civilians, and Armory Workers." In this full-day program, students experience life as armory workers, as Civil War soldiers, and as civilians on the home front. Reservations are required, and a fee applies. Call Joanne Gangi_Wellman for reservations and information at 413/734-8551 ext. 236, Joanne_gangi@nps.gov

*From "History Lost and Found," *Journal of the National Trust for Historic Preservation*, Winter 2002.

Connections to the Massachusetts Curriculum Framework Standards:

History and Social Science

USI.28 Explain the emergence and impact of the textile industry in New England and industrial growth generally throughout antebellum America. (H, E)

- A. the technological improvements and inventions that contributed to industrial growth

English/Language Arts

2.4: Integrate relevant information gathered from group discussions and interviews for reports.

19.23: Write multi-paragraph compositions that have clear topic development, logical organization, effective use of detail, and variety in sentence structure.

23.11: Organize ideas for writing comparison-and-contrast essays.

ELPBO (English Language Arts Proficiency Benchmarks and Outcomes)

S.3.42 States a position and supports/justifies it.

S.3.65 Participates in classroom discussions and other academic interactions, using basic and complex sentence structures.

.



Image 1: Gunstock

3131X

T. BLANCHARD.
Turning Irregular Forms.

Patented Sept. 6, 1819.

Date altered by act of Congress to Jan. 20, 1820.

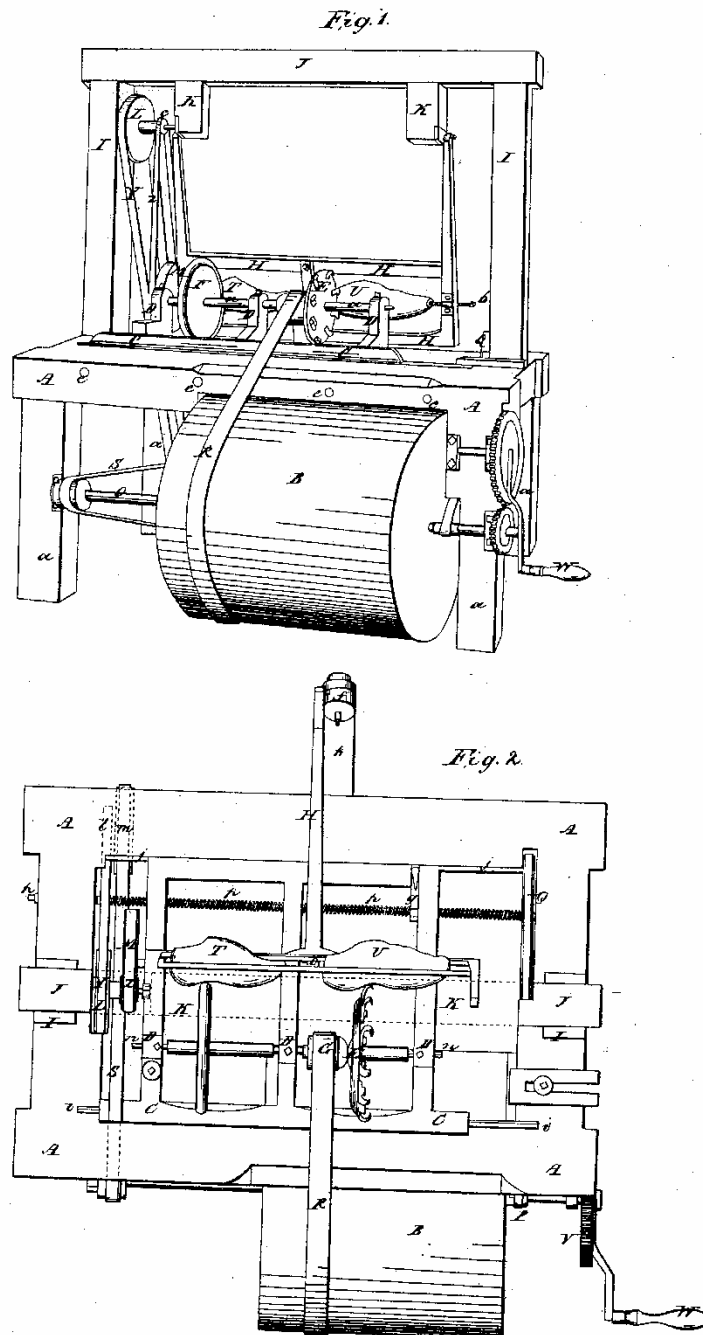


Image 2: Blanchard Lathe – Patent Drawing

Source: Blanchard Lathe Patent Drawing
from United States Patent and Trademark Office: <http://www.uspto.gov>
(Patent number search for X3131)

Pantograph Activity Sheet

The pantograph is a device used for making exact copies of a design or drawing on paper. While some pantographs can enlarge or reduce the drawing, this one is designed to reproduce the drawing in its original size.

This activity demonstrates the principle behind the Blanchard Lathe, which enables a worker to make many identical gunstocks from one pattern.

For each pantograph, you will need:

- 2 sharp pencils, each at least 5 inches long
- one wooden (or sturdy plastic) 12-inch ruler
- masking tape
- gunstock pattern (below)
- drawing paper large enough for creating new gunstocks

Directions:

Step 1:

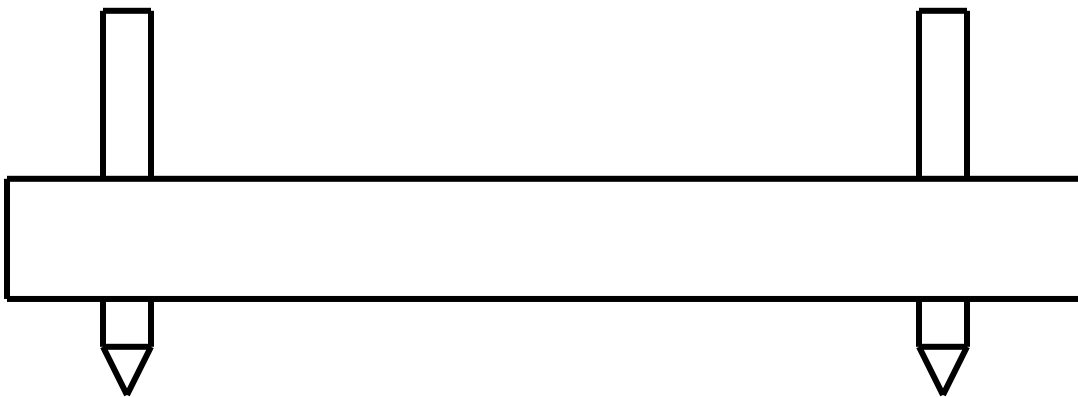
Look at the gunstock pattern. Make an exact copy of this pattern, using only a pencil and paper.

How successful were you? Was your copy exactly the same as the original? Precision is important.

Step 2:

Now follow the directions below to make a pantograph you can use to make an exact copy of the gunstock pattern.

Find the 1-inch mark on the ruler. Tape one pencil to the ruler so it is perpendicular to the ruler at the ruler's 1-inch mark. Tape the other pencil at the ruler's 11-inch mark. Try to keep ruler level. See the diagram below for a guide.

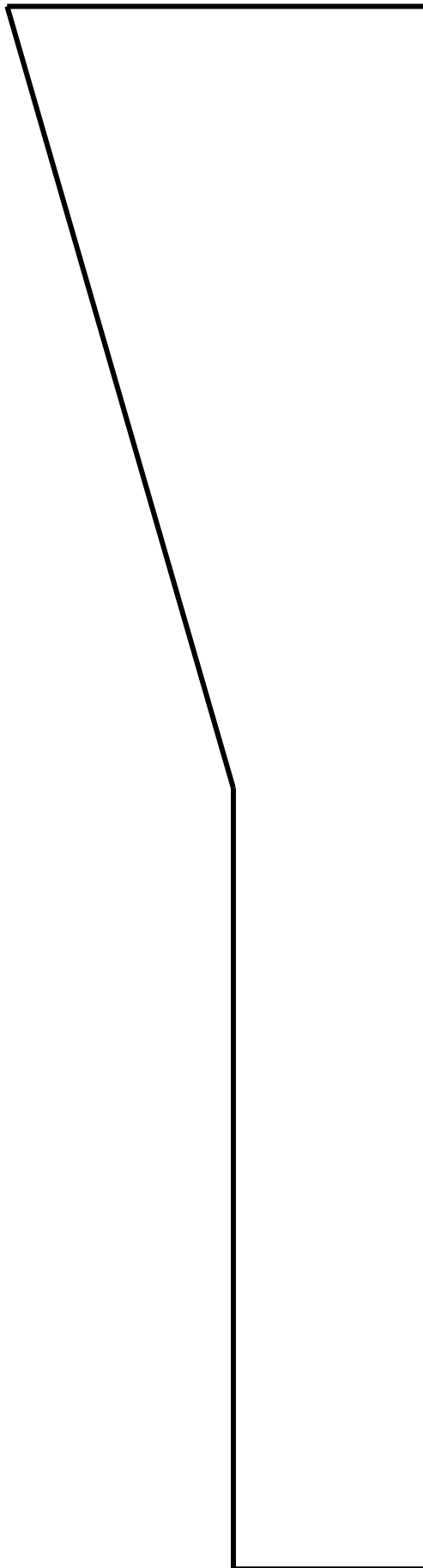


Starting at one corner of the gunstock pattern, trace around it with one of the pencils. The tracing pencil is the “leader” pencil. The other pencil is the “follower” pencil, which transfers the pattern on the drawing paper. Steady both pencils, but allow the “follower” pencil to move freely. The more you practice the technique, the better your new, “precisely reproduced” gunstocks will be.

Which process produced the more accurate pattern? Think both about the work to be done and the role of the worker. What are the benefits and challenges of using the pantograph over free-hand drawing the pattern?

Step 3:

This drawing is two-dimensional. The Blanchard Lathe works to create three-dimensional objects. Select a three-dimensional object, and, using the pantograph, demonstrate how the lathe would cut into the surface of the wood to replicate the object. Hold an object and run the “leader” pencil over the surface. Watch the way the other follows the movement. Imagine a lathe cutting into a surface until it reaches the same depth as the “leader.”



Exploration Handout

Directions: Use the primary and secondary sources provided to answer the question that corresponds to your group number. Be sure to note the evidence that supports your answer. List the resource in the appropriate column, indicating whether it is a primary or secondary resource.

Group ____

Question _____

Answer	Primary Source	Secondary Source

Document 1

“Manufacturing Muskets at the U.S. Armory in Springfield Massachusetts

WE devote page 605 to a series of illustrations of the UNITED STATES ARMORY AT SPRINGFIELD, the largest establishment of the kind in the United States, and one of the largest in the world. It is now a scene of unusual activity and interest.

The weapons chiefly made at this armory are rifled muskets and bayonets. The army rifle, which is known as the Springfield pattern, is now used by the bulk of our volunteers, many regiments having been supplied from the armory since the war began. It is very similar in its principles and construction to the long Enfield rifle, which is considered the best piece in existence by British riflemen. We can not, of course, undertake, in the limits of this article, to give any description of the various processes by which the Springfield rifle is made. It consists of forty-seven separate pieces, all put together with the aid of screws and springs ; in the manufacture of these forty-seven pieces no less than 396 separate operations are performed by different workmen. The welding, boring, smoothing, rifling, stocking, proving, etc., will all be best understood from the illustrations. Each operation is conducted by experienced men, under the general direction of the commanding officer; the system of individual responsibility is so thoroughly carried out that every workman accounts to the Government for the value of each piece of work which may prove to be defective through his carelessness or unskillfulness. Thus, one out of every sixty gun-barrels is said to burst when proved. The bursted barrel is instantly examined, the cause of the accident detected by the nature of the rent, and the cost of the barrel charged to the man who had charge of that part of the work.

The manufacture of bayonets is also very active at Springfield. Bayonets, as is known, are now "milled," not ground, and their manufacture is thus rendered less destructive to the workmen. After they are made, they are tested like the muskets—weights are hung from their point, and it is sprung by the inspector with its point on the floor. If it is too highly tempered it will break; if not sufficiently tempered it will bend. In either case the workman must account for its value.

So many rifles and bayonets are now being turned out of the Springfield Armory, that if our armies lost theirs in every battle they could be replaced in a very short time. The new Arsenal at Springfield was built to contain 500,000 muskets or rifles. It was well stocked when the traitor Floyd became Secretary of War; he depleted it to fill the arsenals at the South which have been robbed by the rebels.”

Source: “The Springfield Armory,” Harper's Weekly, September 21, 1861. (Article page 607, illustration page 605)



Document 2

Excerpt, page 157: "Division of Labor"

DIVISION OF LABOR

"We have said that the number of separate parts which go to compose a musket is forty-nine; but this by no means denotes the number of distinct operations required in the manufacture of it--for almost every one of these forty-nine parts is subject to many distinct operations, each of which has its own name, is assigned to its own separate workman, and is paid for distinctly and by itself, according to the price put upon it in the general tariff' of wages. The number of operations thus separately named, catalogued and priced, is three hundred and ninety-six.

"These operations are entirely distinct from one another--each constituting, as it were, in some sense a distinct trade, so that it might be quite possible that no one man in the whole establishments should know how to perform any two of them. It is quite certain, in fact, that no man can perform any considerable number of them. They are of very various grades in respect to character and price--from the welding of the barrel which is in some points of view the highest and most responsible of all--down to the cutting out of pins and screws of the most insignificant character. They are all however regularly rated, and the work that is performed upon them is paid for by the price."

"The fashion and form of every one of the component portions of the arm are very exactly and rigidly determined by the machinery that is employed in making it." (p. 158)

Source: "The Armory at Springfield," New Harper's Monthly, July 1852.
Forge of Innovation site (<http://www.forgeofinnovation.org>)

Page address: http://www.cesd.umass.edu/Forge_of_Innovation/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/3_abbot_13.html

Document 3

"Should there be any such flaw [in the barrel], however deeply it may be concealed...it is sure to be exposed at last, to the mortification and loss of the workman, in the form of a great gaping rent, which is brought out from it under the inexorable severity of the test to which the work has finally to be subjected." (p. 148)

"We say to the loss as well as to the mortification of the workman, for it is a principle that pervades that whole establishment...that each workman bears the whole loss that is occasioned by the failure of his work to stand its trial, from whatever cause the failure may arise. As a general rule each workman stamps every piece of work that passes through his hands with his own mark...the various parts thus marked are subject to very close inspection...and whenever any failure occurs, the person who is found to be responsible for it is charged with the loss. He loses not only his own pay for the work which he performed upon the piece in question, but for the whole value of the piece at the time that the defect is discovered. That is, he has not only to lose [the pay for] his own labor, but he must also pay for all the other labor expended upon the piece, which through the fault of his work becomes useless...It is immaterial whether the misfortune in such cases is occasioned by accident, or carelessness, or want of skill. In either case, the workman is responsible." (p. 148)

Source: "The Armory at Springfield," New Harper's Monthly, July 1852.
Forge of Innovation site (<http://www.forgeofinnovation.org>)

Page address: http://www.cesd.umass.edu/Forge_of_Innovation/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/3_abbot_04.html

Document 4

“In fact many persons might regard [this policy] as a somewhat severe and rigid rule in any case—and it would, perhaps, very properly be so considered, were it not that this responsibility is taken into account in fixing the rate of wages; and the workmen being abundantly able to sustain such a responsibility do not complain of it. The system operates on the whole in the most salutary manner, introducing, as it does, into every department of the Armory, a spirit of attention, skill, and fidelity, which marks even the countenances and manners of the workmen, and is often noticed and spoken of by visitors. In fact none but workmen of a very high character for intelligence, capacity, and skill could gain admission to the Armory--or if admitted could long maintain a footing there.

The welders are charged one dollar for every barrel lost through the fault of their work. They earn, by welding, twelve cents for each barrel; so that by spoiling one, they lose the labor which they expend upon eight. Being thus rigidly accountable for the perfection of their work, they find that their undivided attention is required while they are performing it.” (p. 149)

Source: “The Armory at Springfield,” New Harper's Monthly, July 1852.
Forge of Innovation site (<http://www.forgeofinnovation.org>)

Page address: http://www.cesd.umass.edu/Forge_of_Innovation/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/3_abbot_05.html

Document 5

Page 158, "Assembling the Musket"

"The component parts of the musket are all made according to one precise pattern, and thus when taken up at random they are sure to come properly together. There is no individual fitting required in each particular case. Any barrel will fit into any stock, and a screw designed for a particular plate or band, will enter the proper hole in any plate or band of a hundred thousand. There are many advantages which result from this precise conformity to an established pattern in the components of the musket. In the first place the work of manufacturing it is more easily performed in this way. It is always the tendency of machinery to produce similarity in its results, and thus although where only two things are to be made it is very difficult to get them alike, the case is very different where there is a call for two hundred thousand. In this last case it is far easier and cheaper to have them alike than to have them different; for in manufacturing on such a scale a machinery is employed, which results in fashioning every one of its products on the precise model to which the inventor adapted the construction of it. Then, besides, a great convenience and economy results from this identity of form in the component parts of the musket, when the arms are employed in service. Spare screws, locks, bands, springs, &c., can be furnished in quantities, and sent to any remote part of the country wherever they are required; so that when any part of a soldier's gun becomes injured or broken, its place can be immediately supplied by a new piece, which is sure to fit as perfectly into the vacancy as the original occupant. Even after a battle there is nothing to prevent the surviving soldiers from making up themselves, out of a hundred broken and dismantled muskets, fifty good ones as complete and sound as ever, by rejecting what is damaged, and assembling the uninjured parts anew." (p. 158)

Source: "The Armory at Springfield," New Harper's Monthly, July 1852.
Forge of Innovation site (<http://www.forgeofinnovation.org>)

Page address: http://www.cesd.umass.edu/Forge_of_Innovation/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/3_abbot_14.html

Document 6

Excerpt describing the Blanchard Lathe (page 157)

"A gun stock, with all the innumerable cavities, grooves, perforations, and recesses necessary to be made in it, to receive the barrel, the lock, the bands, the ramrod, and the numerous pins and screws, all of which require a separate and peculiar modification of its form, is perhaps as irregular a shape as the ingenuity of man could devise--and as well calculated as any shape could possibly be to bid defiance to every attempt at applying machinery to the work of fashioning it. The difficulties however in the way of such an attempt, insurmountable as they would at first sight seem, have all been overcome, and every part of the stock is formed, and every perforation, groove, cavity, and socket is cut in it by machines that do their work with a beauty, a grace, and a perfection, which awaken in all who witness the process, a feeling of astonishment and delight.

"The general principle on which this machinery operates, in doing its work, may perhaps be made intelligible to the reader by description. The action is regulated by what are called patterns. These patterns are models in iron of the various surfaces of the stock which it is intended to form. Let us suppose, for example, that the large cavity intended to receive the lock is to be cut. The stock on which the operation is to be performed is placed in its bed in the machine, and over it, pendant from a certain movable frame-work of polished steel above, is the cutting tool, a sort of bit or borer, which is to do the work. This borer is made to revolve with immense velocity, and is at the same time susceptible of various other motions at the pleasure of the workman. It may be brought down upon the work, and moved there from side to side, so as to cut out a cavity of any required shape; and such is the mechanism of the machine that these vertical and lateral motions may be made very freely without at all interfering with the swift rotation on which the cutting power of the tool depends. This is effected by causing the tool to revolve by means of small machinery within its frame, while the frame and all within it moves together in the vertical and lateral motions.

"Now if this were all, it is plain that the cutting of the cavity in the stock would depend upon the action of the workman, and the form given to it would be determined by the manner in which he should guide the tool in its lateral motions, and by the depth to which he should depress it. But this is not all. At a little distance from the cutter, and parallel to it is another descending rod, which is called the guide; and this guide is so connected with the cutting tool, by means of a very complicated and ingenious machinery, that the latter is governed rigidly and exactly in all its movements by the motion of the former. Now there is placed immediately beneath the guide, what is called the pattern. that is a cavity in a block of iron of precisely the form and size which it is intended to give to the cavity in the wooden stock. All that the workman has to do therefore, when the machine is put in motion is to bring the guide down into the pattern and move it about the circumference and through the centre of

it. The cutting tool imitating precisely the motions of the guide, enters the wood, and cutting its way in the most perfect manner and with incredible rapidity, forms an exact duplicate of the cavity in the pattern. The theory of this operation is sufficiently curious and striking--but the wonder excited by it is infinitely enhanced by seeing the work done. It is on this principle substantially that all the machines of the Stocking Shop are constructed; every separate recess, perforation, or groove of the piece requiring of course its own separate mechanism. The stocks are passed from one of these engines to another in rapid succession, and come out at last, each one the perfect facsimile of its fellow."

Source: "The Armory at Springfield," New Harper's Monthly, July 1852.
Forge of Innovation site (<http://www.forgeofinnovation.org>)

Page address: [http://www.cesd.umass.edu/Forge_of_Innovation/Springfield_Armory_1812-1865/Themes/Craftsmen to Workers/Daily Work/3_abbot 13.html](http://www.cesd.umass.edu/Forge_of_Innovation/Springfield_Armory_1812-1865/Themes/Craftsmen_to_Workers/Daily_Work/3_abbot_13.html)

Document 7

"As early as July 1799, he explained to worried officials that his factory would embody a 'new principle' of manufacturing: 'One of my primary objects,' he wrote to Secretary of the Treasury Oliver Wolcott, 'is to form the tools so the tools themselves shall fashion the work and give to every part its just proportion—which when once accomplished, will give expedition, uniformity, and exactness to the whole. . . . In short, the tools which I contemplate are similar to an engraving on a copper plate from which may be taken a great number of impressions perceptibly alike.'

"This is a description, and an elegant one, of the principle of 'interchangeable parts.' If machine tools make parts of a weapon (or other product) so 'perceptibly alike' that broken parts can be replaced without special fitting, then the parts are said to be interchangeable."

Source: "Eli Whitney's Other Talent." Peter Baida. *American Heritage*, May/June 1987.

Volume 38, Issue 4.

Page address: http://www.americanheritage.com/articles/magazine/ah/1987/4/1987_4_22.shtml

Document 8

Letter of Thomas Jefferson to Patrick Henry (Governor of Virginia) describing a new process of manufacturing muskets

PARIS, January 24, 1786.

(Same information was included in a letter to John Jay, August 30, 1785)

An improvement is made here in the construction of the musket, which may be worthy of attention. It consists in making every part of them so exactly alike that every part of every one may be used for the same part in any other musket made by the same hand. The government here has examined and approved the method, and is establishing a large manufactory for the purpose. As yet the inventor has only completed the lock of the musket on this plan. He will proceed immediately to have the barrel, stock and their parts executed in the same way. I visited the workman. He presented me the parts of 50 locks taken to pieces and arranged in compartments. I put several together myself, taking the pieces at hazard as they came to hand, and found them to fit interchangeably in the most perfect manner. The tools by which he effects this have, at the same time, so abridged the labour that he thinks he shall be able to furnish the musket two livres cheaper than the King's price. But it will be two or three years before he will be able to finish any quantity.

Source: Thomas Jefferson, *The Works of Thomas Jefferson*, Vol. IV (1782-1786). (1904).
Correspondence and Miscellaneous Writings, 1786.

Page address: http://oll.libertyfund.org/Texts/Jefferson0136/Works/Vol04/HTMLs/0054-04_Pt06_1786.html

Document 9

Letter from Thomas Jefferson to James Monroe, introducing Eli Whitney

J. MSS.

WASHINGTON, Nov. 14, 1801.

Dear Sir,

—The bearer hereof is Mr. Whitney at Connecticut a mechanic of the first order of ingenuity, who invented the cotton gin now so much used in the South; he is at the head of a considerable gun manufactory in Connecticut, and furnishes the U. S. with muskets undoubtedly the best they receive. He has invented molds and machines for making all the pieces of his locks so exactly equal, that take 100 locks to pieces and mingle their parts and the hundred locks may be put together as well by taking the first pieces which come to hand. This is of importance in repairing, because out of 10 locks e.g. disabled for the want of different pieces, 9 good locks may be put together without employing a smith. Leblanc in France had invented a similar process in 1788 and had extended it to the barrel, mounting & stock. I endeavored to get the U. S. to bring him over, which he was ready for on moderate terms. I failed and I do not know what became of him, Mr. Whitney has not yet extended his improvements beyond the lock. I think it possible he might be engaged in our manufactory of Richmd. tho' I have not asked him the question. I know nothing of his moral character. He is now on his way to S. Carola. on the subject of his gin. Health & happiness cum cæteris votis.

Source: Thomas Jefferson, *The Works of Thomas Jefferson, Vol. IX (1799-1803)*. (1904).

Page address: http://oll.libertyfund.org/Texts/Jefferson0136/Works/0054-09_Bk.html

Document 10

Eli Whitney to Secretary of the Treasury Oliver Wolcott, Sept. 30, 1799

“I am persuaded that Machinery moved by water adapted to this Business would greatly diminish the labor and facilitate the manufacture of this Article. Machines for forging, rolling, floating, boring, grinding, polishing, etc. may all be made use of to advantage....” (May 13, 1798)."

“...One of my primary objectives is to form the tools so that the tools themselves shall fashion the work and give to every part its just proportions, which once accomplished, will give exceptional uniformity to the whole” (July 30, 1799).

Source: Eli Whitney Museum Website. “The Factory.”

Page address: <http://www.eliwhitney.org/factory.htm>

Document 11

“Arms manufacturing had changed little in the 18th century. In a long apprenticeship, gunsmiths learned to forge, carve and shape each intricate piece of a musket. European nations were reluctant to let these craftsmen emigrate.

"Facing a shortage of skilled, affordable craftsmen, Whitney built a plan: one of my (sic) primary objects is to form the tools so the tools themselves shall fashion the work. Create tools to ease the skill required of workers. Drive tools by water. Organize work so that a man need master the fashioning of but a few parts. Whitney's factory will produce a strategy of working that will shape 19th century America. It is a change in organization and process that will lead to vast material changes.”

Source: Eli Whitney Museum Website:

Page address: <http://www.eliwhitney.org/change.htm>

Document 12

“In 1807 the manufacture of rifles and pistols involved six separate branches of labor: barrel making, lock forging, lock filing, brazing, stocking, and finishing. The completion of each limb required not only different skills, but also special tools for each operation. As artisans completed their tasks, they submitted their work to the master armorer for inspection. He, in turn, sent the parts, where a ‘finisher’ filed and fitted them, assembling the completed weapon. In other words, each stand turned over to the arsenal storekeeper represented a composite product, the work of several different hands. Yet, despite the rudimentary division of labor involved in the manufacturing process, each gun remained essentially a handcrafted process ([Smith, 1977, p. 79](#)).”

From
The Springfield Armory's role in developing interchangeable parts
Robert C. Ford
Management Decision Volume 43 Number 2 2005 pp. 265-277

(Note)Smith, M.R. (1977), *Harpers Ferry Armory and the New Technology*, Cornell University Press, Ithaca, NY, .

Document 13

"For Springfield Armory and, especially, the United States, the pay-off for the many decades of labor and investment in developing mechanized interchangeable manufacture of military shoulder arms occurred in the Civil War years of 1861-65. Twenty years before the first shots were fired between Federal and Confederate forces, production of fully interchangeable muskets at Springfield Armory became, for the first time, a reality. Fifteen years later, Springfield Armory began production of the revolutionary new US Model 1855 Rifle Musket – a weapon that set the pattern for those shoulder arms used by both sides in the Civil War five years later.

"In the first year of the war, Springfield Armory was able to make about 40,000 of these powerful and highly accurate weapons – not nearly enough for the demands of the Union armies, however. As a result, the nation turned to supplies of shoulder arms wherever they could be found. For many regiments, this meant that they fought with serviceable foreign weapons until enough "Springfields" could be had. They had not long to wait!

"The second year of the war found Springfield Armory, the sole federal armory following the destruction of Harper's Ferry Armory in the first weeks of the war, kicking its mechanized production system into high gear. Manufacture of an improved and simplified weapon, the US Model 1861 Rifle Musket, increased more than fourfold that year to about 174,000 only to increase again in 1863, with production of a further simplified rifle musket, the US Model 1863, to about 240,000. The next year, about 250,000 were made with as up to a thousand made on some days. By the war's end, Springfield Armory had provided more rifle muskets than those of all private contractors combined."

Source: *Forge of Innovation* site (<http://www.forgeofinnovation.org>) "Preserving the Union"

Page Address:

http://www.cesd.umass.edu/Springfield_Armory/Themes/Technological_Development/Preserving_the_Union/index.html

Document 14

Expanding on the Armory's pre-war manufacturing methods witnessed a ten-fold increase in the workforce to, at times, more than 2800 men. With relatively modest expansion of the Armory, they made over 800,000 rifle-muskets during the war, or about 11% more muskets than the Armory made during all the preceding 66 years of its operation. This output represented more than one quarter of all shoulder arms made or procured for the Army in the war, and about 54% of all standard issue rifle-muskets. The Armory out-produced more than thirty private contractors making the Army rifle-musket, while providing them with gages, inspectors, and models. The 645 Springfield rifle muskets displayed nearby in the "Organ of Muskets" represents about a single day's production at the height of the Civil War.

Source: Exhibit text from Springfield Armory National Historic Site

For more information see Page address: <http://www.nps.gov/spar/historyculture/organ-of-muskets.htm>

Document 15

“Before the Civil War, musket production at the Armory typically ran 800 a month. At its wartime peak in 1864, production sometimes reached 1,000 muskets a day. The number of different jobs at the Armory increased from 113 to 390 during the war.”

Source: Springfield Armory bulletin

Page address: <http://www.nps.gov/spar/historyculture/upload/National%20Armory%20bulletin%201106.doc>

Document 16

Arms Manufactured at the United States Armory at Springfield, Mass. Percussion Muskets				
Year	M1855	M1861	M1863	M1864
1861	9,002	33,572		
1862		173,809		
1863		57,748	183,064	
1864			90,201	157,463
1865				97,577
TOTAL	9,002	265,129	273,265	255,040

Source: Graph of musket production, 1861-1865.
Forge of Innovation site (<http://www.forgeofinnovation.org>)

Page Address:
http://www.cesd.umass.edu/Springfield_Armory/Themes/Technological_Development/Preserving_the_Union/5_visual.html